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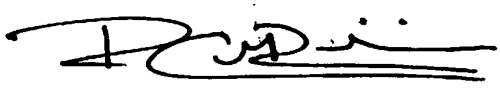

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A semiconductor structure and a method for fabricating a strain cd layer on a single crystal substrate

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A Semiconductor Structure and a Method for Fabricating a Strained Layer on a Single Crystal Substrate

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A Semiconductor Structure and a Method for Fabricating a Strained Layer on a Single Crystal Substrate

The present invention relates to a semiconductor structure having a strained crystalline layer formed on a single crystal substrate and further to a method for fabricating such a semiconductor structure.

A high degree of strain in a thin crystalline layer such as a silicon layer results in an enhancement of electron and hole mobility in that layer which is advantageous for a continual improvement of speed or a decrease of power of electronic devices.

Strain in silicon layers can be induced, for instance by growing a thin silicon layer on a relaxed SiGe layer with a high concentration of germanium. Since silicon is the smaller atom, the stress between silicon and such a SiGe layer increases gradually with increasing Ge concentration. Therefore, more favourable strain values can be achieved when the germanium concentration of the SiGe layer is as large as possible.

US 2002/0084000 A1discloses a method and a semiconductor structure in which a GeSi layer with a gradual increasing germanium content is grown on a silicon substrate up to a germanium content of about 50%. With increasing germanium content of the graded GeSi layer, cracks and a high number of threading dislocations occur in the layer. In order to remove a cross-hatch pattern on the surface of the grown GeSi layer, a surface planarization step such as a Chemical Mechanical Polishing is applied on the GeSi surface. The planarization step prevents a continued roughening of the surface and leads to dislocation blocking in a continued grading. Thereafter, the germanium content of the GeSi is further increased until a pure Ge layer is brought on the top of the structure.

WO 02/15244 A2 describes a method and a semiconductor structure to provide a SiGe buffer layer serving as a seed layer for a strained silicon film. In the method, a SiGe layer is deposited on a single crystal silicon wafer, wherein the germanium concentration is gradually increased from the silicon substrate to 25% germanium. Then, a relaxed SiGe cap layer is deposited, having a final Ge composition of 25%.

The process of growing a relaxed GeSi layer is very complex. The growth generates a very high density of misfit dislocations and cross-hatch of the SiGe layer. Furthermore, the above method is limited to a germanium content below 40% as a crystal defect density below $10^4 cm^{-2}$ is targeted.

As stated above, it is very difficult to get a high-strained silicon layer with a low defect density on a single crystal substrate with the above technologies.

It is therefore the object of the present invention to provide a semiconductor structure having a high-strained crystalline layer with a low crystal defect density on a single crystal substrate, which can be fabricated by an easy method.

The object is solved with a semiconductor structure comprising: a semiconductor substrate of a first material comprising germanium and/or an A(III)-B(V)-semiconductor; at least one first crystalline epitaxial layer being a composition comprising the first material; and at least one second crystalline epitaxial layer; wherein the first layer is located between the substrate and the second layer; and the second layer is of a second material which is chemically different from the first material.

The germanium and/or A(III)-B(V)-semiconductor comprising substrate is a very good basis for a good stress relaxation in at least a part of the first layer, resulting in a low crystal defect density in at least this part of the first layer. The first layer can well accommodate the stress between the substrate material and the material of the second layer which results in a high quality of the second layer. Due to the different material characteristics of the first and second layers, it is possible to create a high strain in the second layer. In the inventive structure, the way between a relaxed part of the first layer and the substrate can be shortened so that a high germanium and/or A(III)-B(V)-semiconductor concentration can be reached in the first layer leading to a high strain in the second layer.

In a favourable embodiment of the invention, the semiconductor substrate comprises a single crystal germanium wafer, an A(III)-B(V)-semiconductor wafer, an epitaxial germanium layer or an epitaxial A(III)-B(V)-semiconductor layer. The wafer as well as the epitaxial layers provide a high content of germanium or of the A(III)-B(V)-semiconductor, preferably of about 100%, on which a high quality first layer can be provided with a high

content of germanium or of the A(III)-B(V)-semiconductor, respectively. The germanium wafer or the A(III)-B(V)-semiconductor wafer forms a good and stable basis of the semiconductor structure and allows a good handling of the semiconductor structure in the fabrication process.

According to another preferable example of the present invention, the second layer is a silicon layer. This way, a high strained silicon layer with a very good crystal quality can be provided on the single crystal substrate.

According to a further embodiment of the invention, the first layer comprises at least one buffer layer in which the germanium and/or A(III)-B(V)-semiconductor content decreases from the substrate to the second layer. Starting from a high concentration of germanium and/or A(III)-B(V)-semiconductor in the substrate, the germanium and/or A(III)-B(V)-semiconductor concentration of the first layer can be decreased to a high value with a good relaxation of the lattice of the first layer. This results in a first layer for example of a GeSi layer, having at least on top of the first layer a high quality layer, such as a relaxed GeSi layer, with a high germanium and/or A(III)-B(V)-semiconductor content.

According to another embodiment of the invention, the germanium and/or A(III)-B(V)-semiconductor content decreases to a proportion between about 40% and 80%, preferably to about 50 to 80% or about 60 to 80%. The amount of about 40 to 80% germanium and/or A(III)-B(V)-semiconductor makes it possible to grow a strained layer on the first layer such as a GeSi layer, whereas a percentage of about 50 to 80% is more favourable to get a higher strained layer on top of the first layer and a percentage of about 60 to 80% germanium and/or A(III)-B(V)-semiconductor is the most favourable region to produce a very high-strained layer on the first layer.

In a further example of the present invention, the first layer comprises at least one relaxed layer with a silicon content of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%. The percentage of about 20 to 60% silicon can induce a strain in a layer on top of the first layer such as a GeSi layer, whereas a percentage of about 20 to 50% can result in higher strains and a percentage of about 20 to 40% silicon is the most favourable region to get a high-strain characteristic of a layer on top of the first layer.

In a further favourable embodiment of the invention, the first layer comprises at least on portion in which the crystal defect density is below 10^4 cm^{-2}. The very good crystallinity of that portion influences the growth of the second layer so that it can be grown with a very high quality, resulting in very good electronic characteristics of the second layer.

According to another advantageous embodiment of the invention, the second layer has a thickness below 50 nm. This thickness is below a critical thickness at which the second layer would become thermodynamically unstable. Therefore, a very high strain can build up in the second layer which enhances the carrier mobility resulting in very good conductivity of the second layer.

In a further preferable embodiment of the present invention, the first layer and/or the second layer comprises carbon. Carbon, preferably of a low content such as below a few percent carbon, and even below 1% carbon, results in a good dopant stability and strain level of the first layer and/or the second layer.

The object of the invention is further solved by a semiconductor structure comprising: a semiconductor substrate of a first material comprising germanium and/or an A(III)-B(V)-semiconductor; and at least one first crystalline epitaxial layer; wherein the first layer comprises a buffer layer (3) comprising germanium and/or the A(III)-B(V)-semiconductor the content of which decreases from the substrate to a top of the buffer layer.

The inventive structure is advantageous for using as an intermediate product for fabricating a strained crystalline layer on the single crystal substrate. The structure allows a continuous relaxation of strain in at least a part of the first layer resulting in a very low crystal defect density in this part the first layer. Starting with a germanium and/or A(III)-B(V)-semiconductor comprising substrate, it is possible to lower the germanium and/or A(III)-B(V)-semiconductor content in the buffer layer over a short way to a high value. Based on this, the second layer can be grown as a high strained layer with a very good crystallinity.

According to a preferable embodiment of the invention, the semiconductor substrate comprises a single crystal germanium wafer, an A(III)-B(V)-semiconductor wafer, an epitaxial germanium layer or an epitaxial A(III)-B(V)-semiconductor layer. The wafer as well

as the epitaxial layers provide a high content of germanium or of the A(III)-B(V)-semiconductor which is preferably about 100%, on which the first layer can be provided effectively with a high concentration of germanium or of the A(III)-B(V)-semiconductor, respectively. The germanium or the A(III)-B(V)-semiconductor wafer gives the semiconductor structure a good stability which is favourable for the handling of the semiconductor structure in the fabrication process.

In another favourable embodiment of the invention, the germanium and/or A(III)-B(V)-semiconductor content of the first layer increases to a proportion between about 40 to 80%, preferably about 50 to 80% or about 60 to 80%. The germanium and/or A(III)-B(V)-semiconductor content of about 40 to 80% allows growing of a strained layer on top of the first layer such as a GeSi layer, whereas the percentage of about 50 to 80% germanium and/or A(III)-B(V)-semiconductor is more favourable to get higher strain results and the percentage of about 60 to 80% is the most favourable region to produce a high-strained layer on the first layer.

In a yet further embodiment of the present invention, the first layer comprises at least one relaxed layer with a silicon content of about 20 to about 60%, preferably about 20 to 50% or about 20 to 40%. The relaxed layer with the silicon content of about 20 to about 60% allows a good growth of a strained second layer such as a silicon layer on top of the relaxed layer, whereas the percentage of about 20 to 50% is more favourable to get higher strain results in the strained second layer and the percentage of about 20 to 40% percent is the most favourable region to produce a high strained second layer on top of the relaxed layer.

In yet another preferable embodiment of the invention, the first layer comprises at least one portion in which the crystal defect density is below 10^4 cm^{-2}. This low defect density allows growing of a high quality second layer.

According to a further embodiment of the present invention, the first layer comprises carbon. Carbon, preferably of a low content such as below a few percent carbon, and even below 1% carbon, results in a good dopant stability and strain level of the first layer.

In another advantageous embodiment of the present invention, the structure further comprises at least one second crystalline epitaxial layer. The second layer can be grown on the first layer resulting in a high quality strained crystalline layer.

According to yet another favourable example of the present invention, the second layer is a silicon layer. This way, a high strained silicon layer with a very good crystallinity can be provided.

In a further preferable example of the invention, the second layer has a thickness below 50 nm. At this thickness, the second layer is thermodynamically stable. Thus, a high strain can build up in the second layer, resulting in an increase of carrier mobility to get a very good conductivity of the second layer.

The object of the invention is additionally solved by a method for fabricating a semi-conductive structure, comprising: providing a semiconductor substrate of a first material comprising germanium and/or an A(III)-B(V)-semiconductor, in a first step; providing at least one first crystalline epitaxial layer, in a second step; and providing at least one second crystalline epitaxial layer of a second material which is different from the first material, on said first layer, in a third step, wherein the first layer is provided intermediate between the substrate and the second layer.

The inventive method provides a single but efficient sequence of steps to produce a semiconductor structure which has on top a second material which material characteristics are different from the substrate material. Therefore, a strain in the second layer can easily build up. The first layer works as an intermediate layer between the substrate and the second layer and can therefore be used to adapt the material characteristics between the first and the second material to get a high quality semiconductor structure with a low defect density. In the second step, the germanium and/or A(III)-B(V)-semiconductor content of the first layer can be lowered to a high content of germanium and/or the A(III)-B(V)-semiconductor over a short way which can result in a very high strained second layer with a good crystallinity in a short processing time.

In a favourable embodiment of the invention, the second step comprises growing a graded buffer layer wherein a silicon content of the buffer layer is increased during th second step.

Due to this increase of silicon in the buffer layer, the strain in the buffer layer can be step-wisely changed, resulting in the possibility to provide a low defect density layer on top of the buffer layer.

In a further preferable embodiment of the invention, the silicon content of the buffer layer is increased to about 20 to 60%, preferably about 20 to 50% or about 20 to 40%. The silicon content of about 20 to 60% allows growing of a strained second layer such as a silicon layer on top of the buffer layer, whereas the percentage of about 20 to 50% is more favourable to get a high strain result in the second layer and the percentage of about 20 to 40% is the most favourable region to get a high-strained second layer on top of the buffer layer.

In yet another advantageous embodiment of the invention, the second step comprises growing a relaxed layer with a silicon content of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%. With the silicon content of about 20 to about 60%, a strained second layer such as a silicon layer can be grown on the relaxed layer, such as a relaxed GeSi layer, with a high quality whereas the percentage about 20 to 50% silicon is more favourable to get a high strained second layer with a high crystal quality on top of the relaxed layer and a percentage of about 20 to 40% silicon is the most preferable region to come to a very high strained second layer with a high crystal quality.

In a further preferable embodiment of the invention, the third step comprises growing of a silicon layer. This way, a high strained silicon layer with a high quality crystallinity can be provided on a single crystal basis.

The object of the invention is furthermore solved by a method for fabricating a semi-conductive structure comprising: providing a semiconductor substrate of a first material comprising germanium and/or an A(III)-B(V)-semiconductor, in a first step; and providing at least one first crystalline epitaxial layer comprising the first material on the substrate, in a second step; wherein a content of germanium and/or the A(III)-B(V)-semiconductor is decreased in a buffer layer of the first layer during the second step.

The inventive method provides an easy and efficient technology for producing an intermediate product for fabricating a strained crystalline epitaxial layer on a single crystal substrate. The second step provides the first layer in which the germanium and/or A(III)-

B(V)-semiconductor content can be step-wisely reduced over a short way resulting in a high concentration of germanium and/or the A(III)-B(V)-semiconductor and a very low crystal defect density in at least a top region of the first layer. This forms a very good basis to get a very high quality and a high strain of a layer which can be provided on top of the first layer.

In another favourable embodiment of the present invention, the germanium and/or A(III)-B(V)-semiconductor content of the buffer layer is decreased to a proportion of about 40 to 80%, preferably about 50 to 80% or about 60 to 80%. The germanium and/or A(III)-B(V)-semiconductor content of about 40 to 80% allows growing of a strained layer on top of the first layer such as a GeSi layer, whereas the percentage of about 50 to 80% germanium and/or A(III)-B(V)-semiconductor is more favourable to get higher strain results and the percentage of about 60 to 80% is the most favourable region to produce a high-strained layer on the first layer.

In yet another preferable example of the present invention, the buffer layer is grown with a silicon content which is increased during the second step. This allows a good lattice mismatch accomodation between the substrate and a silicon containing layer on top of the first layer.

According to another favourable embodiment of the invention, the silicon content is increased to a proportion of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%. With the silicon content of about 20 to 60%, a strained silicon layer can be brought on top of the first layer, whereas the percentage of about 20 to 50% silicon is more favourable to get high-strain results in a silicon layer on top of the first layer and the percentage of about 20 to 40% silicon is the most favourable region for producing a strained silicon layer on top of the first layer.

In a further advantageous embodiment of the invention, the second step comprises growing a relaxed layer with a silicon content of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%. With the silicon content of about 20 to 60%, a strained silicon layer can be brought with a high crystal quality on top of the relaxed layer, whereas the percentage of about 20 to 50% silicon is more favourable to get high-quality and high-strain results in a silicon layer on top of the relaxed layer and the percentage of about 20 to 40% silicon is the

most favourable region for producing a high strained and high quality silicon layer on top of the relaxed layer.

According to yet another preferable embodiment of the present invention, the method further comprises providing at least one second crystalline epitaxial layer on the first layer, in third step, wherein the first layer is provided between the substrate and the second layer. This method leads to semiconductor structure having a high strained and high crystal quality crystalline layer on a single crystal basis which has very advantageous electronic characteristics.

In a yet further embodiment of the present invention, the third step comprises growing a silicon layer. This way, a high strained silicon layer with a very good crystallinity can be formed on a single crystalline basis wherein the strained silicon layer has a very good conductivity.

In the following, preferable embodiments of the invention are described with reference to the accompanying figures, in which:

Fig. 1 shows schematically a semiconductor structure according to an embodiment of the present invention;

Fig 2 shows schematically a concentration distribution conc. in % versus a thickness x of the semiconductor structure of fig. 1; and

Fig. 3 shows schematically a process flow according to an embodiment of the present invention, for fabricating the semiconductor structure of fig. 1.

Fig. 1 shows schematically a semiconductor structure 1 according to an embodiment of the present invention. The semiconductor structure 1 comprises at the bottom a substrate of a single crystal germanium wafer 2 with a germanium content of about 100%. Preferably, a commonly available germanium wafer of standard size and thickness is used.

In another embodiment of the present invention, the germanium wafer 2 can be replaced by a substrate which has at least on top of the substrate an epitaxial layer which consists

essentially of germanium, an A(III)-B(V)-semiconductor such as GaAs, GaInP or InP or of an alloy or a composition of these materials. In a favourable variant, the substrate can be a GaAs wafer which is covered with a single crystal germanium layer. The substrate 2 can further be doped.

The lower surface of the germanium wafer 2 is indicated by x_0. Although not shown, on the upper surface of the germanium wafer 2, which is indicated by x_1, a thin Ge buffer layer can be brought. On top of that layer, or directly on the upper surface of the germanium wafer 2, a first crystalline epitaxial layer 3, 4 consisting of a buffer layer 3 and relaxed layer 4 is grown with a carbon content below 1%. The buffer layer 3 as well as the relaxed layer 4 consist of a GeSi composition. The buffer layer 3 is grown epitaxially on the germanium wafer 2 and extends from the surface of the wafer 2 corresponding to the thickness x_1 of the semiconductor structure 1 to a thickness x_2. Starting from the thickness x_1, the silicon content of the GeSi layer 3 increases gradually up to the thickness x_2. At or near the thickness x_1, the silicon content of the GeSi buffer layer 3 is about 0%, whereas the silicon content of the buffer layer 3 is at or near the thickness x_2 about 20 to 60%. Correspondingly, the germanium content of the buffer layer 3 is at or near the thickness x_1 about 100%, whereas the germanium content of the buffer layer 3 is at or near the thickness x_2 about 40 to 80%.

The relaxed GeSi layer 4 is grown epitaxially on the buffer layer 3. The relaxed layer 4 has a nearly constant silicon content of about 20 to 60% and a nearly constant germanium content of about 40 to 80%, respectively. The crystal defect density of the relaxed layer 4 is below 10^4 cm^{-2}.

A second crystalline layer 5 is grown epitaxially on the upper surface of the first layer 3, 4, which is indicated by the thickness x_3, so that the first layer 3, 4 is an intermediate layer between the substrate 2 and the second layer 5. This second layer 5 consists of single crystalline silicon and has a thickness below 50 nm. The second layer 5 is strained and has a low crystal defect density. in another embodiment of the invention which is not shown, an additional layer such as a seed or a buffer layer can be located between the first layer 3, 4 and the second layer 5.

Fig. 2 shows schematically a concentration distribution conc. in % versus a thickness x of the semiconductor structure of fig. 1. The reference numerals of fig. 2 which are identical to the reference numerals used with reference to fig. 1 indicate the same parts and components as in fig. 1.

In fig. 2, the continuous line 6 represents the germanium content 6 of the semiconductor structure 1 which is about 100% in the germanium substrate 2. The dashed line 7 represents the silicon content of the semiconductor structure which is about 0% in the germanium substrate 2. In the shown example, the silicon content 7 increases in the buffer layer 3 from 0% to about 30%, whereas the germanium content 6 in the buffer layer 3 decreases to a value of about 70%.

In fig. 2, the increase of silicon 7 and the decrease of germanium 6 is shown as being continuous. Instead of a continuous change, a gradual or a step-by-step change of the content of silicon and/or germanium can be used in the buffer layer 3. Furthermore, there can be one or more regions in the buffer layer 3 in which there is no change of the germanium and/or the silicon content.

The relaxed layer 4 which is on top of the buffer layer 3 in the shown example has a nearly constant proportion between germanium and silicon of about 30% silicon to about 70% germanium.

The relaxed layer 4 is nearly dislocation-free. The crystal defect density of the relaxed layer 4 is below 10^4 cm^{-2}.

The second layer 5 which is grown on the relaxed layer 4, is a strained silicon layer with a silicon content 7 of about 100%, whereas its germanium content 6 is about 0%. The second layer has a carbon concentration below 1% carbon.

In another embodiment of the present invention, the second layer 5 can be of an A(III)-B(V)-semiconductor such as GaAs.

Fig. 3 shows schematically a process flow according to an embodiment of the present invention, for fabricating the semiconductor structure of fig. 1.

Fig. 3 (a) shows a first step of the inventive method, in which the single crystal germanium wafer 2 is provided.

In another embodiment of the invention, a thin germanium buffer layer is grown or deposited on the germanium wafer 2.

Figs. 3 (b) and 3 (c) show partial steps of the second step. In fig. 3(b) the graded buffer GeSi layer 3 is epitaxially grown on top of the wafer 2. During growing of the buffer layer 3, the silicon content of the GeSi layer is slowly, gradually increased from 0% to about 20 to 60%.

As shown in fig. 3 (c), at a ratio between silicon and germanium of about 20 to 60% silicon to about 40 to 80% germanium, a relaxed GeSi layer 4 with a nearly constant ratio of silicon to germanium and a low defect density below 10^4 cm^{-2} is epitaxially grown on the buffer layer 3. The relaxed layer 4 comprises a ratio between silicon and germanium which corresponds approximately to the maximum silicon to germanium ratio of the buffer layer 3. The buffer layer 3 and the relaxed layer 4 form the first layer 3, 4.

With reference to fig. 3 (d), in a third step, the strained silicon layer 5 is epitaxially grown on the relaxed layer 4 up to a thickness below 50 nanometres. This thickness is below a critical thickness at which the strained silicon layer 5 would become thermodynamically unstable, resulting in a formation of misfit dislocations in the layer.

Claims

1. A semiconductor structure comprising:
a semiconductor substrate (2) of a first material comprising germanium and/or an A(III)-B(V)-semiconductor;
at least one first crystalline epitaxial layer (3, 4) being a composition comprising the first material; and
at least one second crystalline epitaxial layer (5);
wherein the first layer (3, 4) is located between the substrate (2) and the second layer (5); and
the second layer (5) is of a second material which is chemically different from the first material.

2. The structure of claim 1,
characterized in that
the semiconductor substrate (2) comprises a single crystal germanium wafer, an A(III)-B(V)-semiconductor wafer, an epitaxial germanium layer or an epitaxial A(III)-B(V)-semiconductor layer.

3. The structure of at least one of the claims 1 or 2,
characterized in that
the second layer (5) is a silicon layer.

4. The structure of at least one of the preceding claims,
characterized in that
the first layer (3, 4) comprises at least one buffer layer (3) in which the germanium and/or A(III)-B(V)-semiconductor content (6) decreases from the substrate (2) to the second layer (5).

5. The structure of claim 4,
characterized in that
the germanium and/or A(III)-B(V)-semiconductor content (6) decreases to a proportion of about 40 to 80% germanium, preferably about 50 to 80% or about 60 to 80%.

6. The structure of at least one of the preceding claims,
characterized in that
the first layer (3, 4) comprises at least one relaxed layer (4) with a silicon content (7) of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%.

7. The structure of at least one of the preceding claims,
characterized in that
the first layer (3, 4) comprises at least one portion in which the crystal defect density is below 10^4 cm^{-2}.

8. The structure of at least one of the preceding claims,
characterized in that
the second layer (5) has a thickness below 50 nm.

9. The structure of at least one of the preceding claims,
characterized in that
the first layer (3, 4) and/or the second layer (5) comprises carbon.

10. A semiconductor structure comprising:
a semiconductor substrate (2) of a first material comprising germanium and/or an A(III)-B(V)-semiconductor; and
at least one first crystalline epitaxial layer (3, 4);
wherein the first layer (3, 4) comprises a buffer layer (3) comprising germanium and/or the A(III)-B(V)-semiconductor the content (6) of which decreases in a direction from the substrate (2) to a top of the buffer layer (3).

11. The structure of claim 10,
characterized in that
the semiconductor substrate (2) comprises a single crystal germanium wafer, an A(III)-B(V)-semiconductor wafer, an epitaxial germanium layer or an epitaxial A(III)-B(V)-semiconductor layer.

12. The structure of at least one of the claims 10 or 11,
characterized in that
the germanium and/or the A(III)-B(V)-semiconductor content (6) of the buffer layer (3) decreases to a proportion of about 40 to 80%, preferably about 50 to 80% or about 60 to 80%.

13. The structure of at least one of the claims 10 to 12,
characterized in that
the first layer (3, 4) comprises at least one relaxed layer (4) with a silicon content (7) of about 20 to about 60%, preferably about 20 to 50% or about 20 to 40%.

14. The structure of at least one of the claims 10 to 13,
characterized in that
the first layer (3, 4) comprises at least one portion in which the crystal defect density is below 10^4 cm^{-2}.

15. The structure of at least one of the claims 10 to 14,
characterized in that
the first layer (3, 4) comprises carbon.

16. The structure of at least one of the claims 10 or 15,
characterized in that
the structure further comprises
at least one second crystalline epitaxial layer (5).

17. The structure of claim 16,
characterized in that
the second layer (5) is a silicon layer.

18. The structure of at least one of the claims 16 or 17,
characterized in that
the second layer (5) has a thickness below 50 nm.

19. The structure of at least one of the claims 15 to 18,
characterized in that
the second layer (5) comprises carbon.

20. A method for fabricating a semiconductor structure, comprising:
providing a semiconductor substrate (2) of a first material comprising germanium and/or an A(III)-B(V)-semiconductor, in a first step;
providing at least one first crystalline epitaxial layer (3, 4), in a second step, wherein the first layer is a composition comprising the first material; and
providing at least one second crystalline epitaxial layer (5) of a second material which is different from the first material, on said first layer (3, 4), in a third step;
wherein the first layer (3,4) is provided intermediate between the substrate (2) and the second layer (5).

21. The method of claim 20,
characterized in that
the second step comprises growing of a buffer layer (3) the germanium and/or the A(III)-B(V)-semiconductor content (6) of which is decreased during the second step.

22. The method of claim 21,
characterized in that
the germanium and/or A(III)-B(V)-semiconductor content (6) of the buffer layer (3) is decreased to a proportion of about 40 to 80%, preferably about 50 to 80% or about 60 to 80%.

23. The method of at least one of the claims 20 to 22,
characterized in that
the second step comprises growing a buffer layer (3) wherein a silicon content (7) of the buffer layer (3) is increased during the second step.

24. The method of claim 23,
characterized in that
the silicon content (7) of the buffer layer (3) is increased to about 20 to 60%, preferably about 20 to 50% or about 20 to 40%.

25. The method of at least one of the claims 20 to 24,
characterized in that
the second step comprises growing a relaxed layer (4) with a silicon content (7) of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%.

26. The method of at least one of the claims 20 to 25,
characterized in that
the third step comprises growing of a silicon layer.

27. A method for fabricating a semiconductor structure, comprising:
providing a semiconductor substrate (2) of a first material comprising germanium and/or an A(III)-B(V)-semiconductor, in a first step; and
providing at least one first crystalline epitaxial layer (3, 4) comprising the first material, in a second step, wherein a content of germanium and/or the A(III)-B(V)-semiconductor (6) is decreased in a buffer layer (3) of the first layer (3, 4) during the second step.

28. The method of claim 27,
characterized in that
the germanium and/or A(III)-B(V)-semiconductor content (6) of the buffer layer (3) is decreased to a proportion of about 40 to 80%, preferably about 50 to 80% or about 60 to 80%.

29. The method of at least one of the claims 27 or 28,
characterized in that
the buffer layer (3) is grown with a silicon content (7) which is increased during the second step.

30. The method of claim 29,
characterized in that
the silicon content (7) is increased to a proportion of about 20 to 60%, preferably about 20 to 50% or about 20 to 40% silicon.

31. The method of at least one of the claims 27 to 30,
characterized in that
the second step comprises growing a relaxed layer (4) with a silicon content (7) of about 20 to 60%, preferably about 20 to 50% or about 20 to 40%.

32. The method of at least one of the claims 27 to 31,
characterized in that
the method further comprises
providing at least one second crystalline epitaxial layer (5), in a third step, wherein the first layer (3, 4) is provided between the substrate (2) and the second layer (5).

33. The method of claim 32,
characterized in that
the third step comprises growing a silicon layer (5).

Abstract

The present invention relates to a semiconductor structure having a strained crystalline layer formed on a single crystal substrate and further to a method for fabricating such a semiconductor structure. It is the object of the present invention to provide a semiconductor structure having a high-strained crystalline layer with a low crystal defect density on a single crystal substrate which can be fabricated by an easy method. The object is solved by a semiconductor structure comprising: a semiconductor substrate of a first material comprising germanium and/or an A(III)-B(V)-semiconductor; at least one first crystalline epitaxial layer, the first layer comprising the first material; and at least one second crystalline epitaxial layer; wherein the first layer is located between the substrate and the second layer; and the second layer is of a second material which is chemically different from the first material. The object is further solved by a method of fabricating the above semiconductor structure.

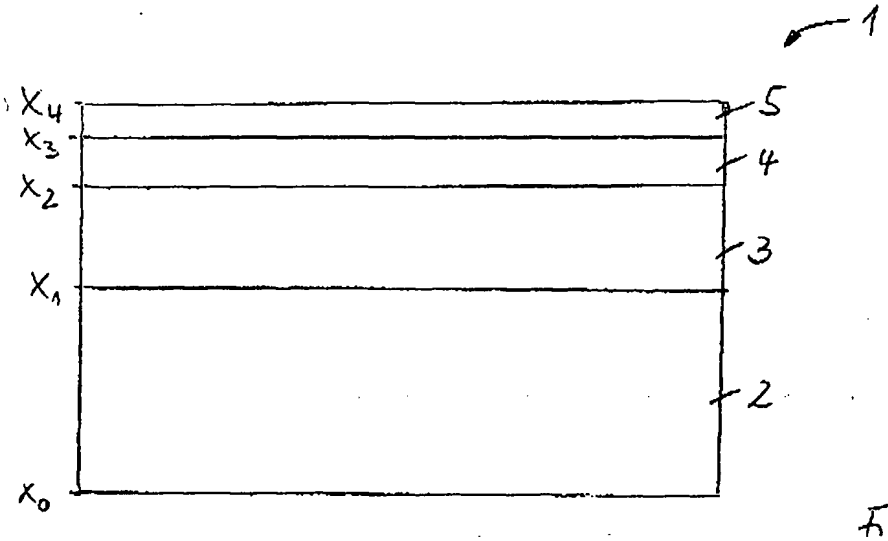

Fig. 1

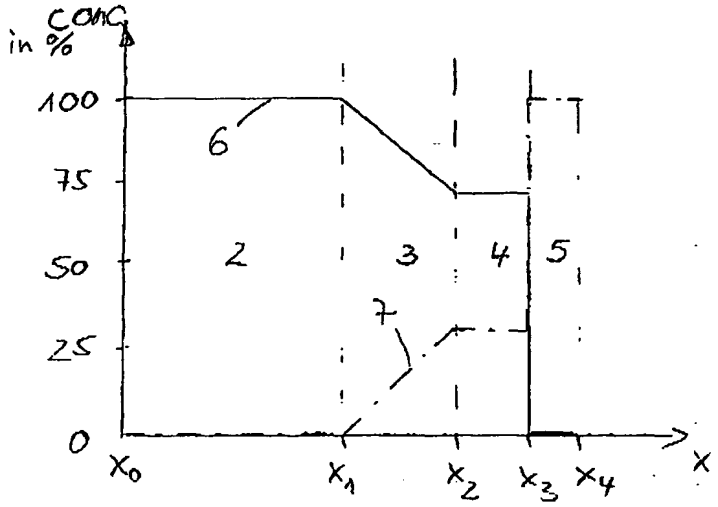

Fig. 2

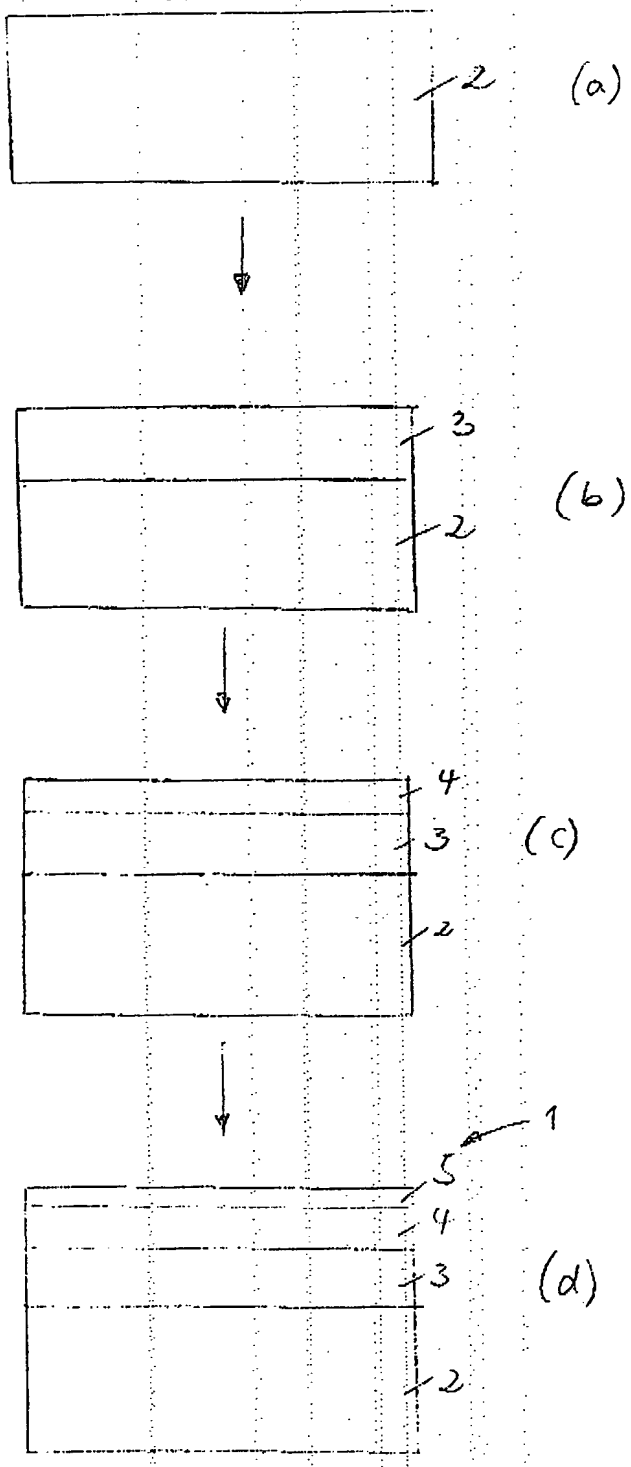

Fig. 3